

UV DOAS Operations
SUMMA Sampling
Shell Deer Park DIAL Project
Cary Secrest, UV DOAS Specialist
U.S. EPA Air Enforcement Division
February 24, 2010

UV DOAS Quality Assurance and Quality Control

The UV DOAS (“DOAS”) analyzer was calibrated for benzene on July 31, 2009, using an 8-point span and offset calibration (“multi-point calibration”). Adjustments were made for spectral fitting and linearity. Multi-point calibrations are done annually, or when the need is indicated by subsequent 4-point span and offset calibration checks. For this project, the quality of the DOAS data was assured by conducting 4-point point span and offset gas calibration checks at the Air Enforcement Division Laboratory, located at the EPA Environmental Science Center, Ft. Meade, Maryland prior to departure to Houston, Texas; and at the City of Houston, Bureau of Air Quality Control laboratory before deployment at Shell Deer Park. A 5-point calibration check was conducted at the City laboratory at the conclusion of the measurements, to add an additional span point check within the range of concentrations encountered in the field.

All gas calibrations were done using a 2% accuracy benzene reference gas standard, and the calibration checks indicated that the measurement bias ranged from 0 to +4% in a span range of 0 ppbV to 197.5 ppbV. The span and offset checks were acceptable and indicated that a new multi-point calibration was not required. Copies of the gas calibration records are included in attachment 1 of this report.

The calibration checks were conducted in volumetric units, corrected to standard temperature and pressure (STP) for consistency with the reference gas standard. Field measurement data was acquired in units of in-situ (not corrected to STP) micrograms per cubic meter, for consistency with the DIAL measurement data.

Daily quality control checks, including detection System Checks and benzene Wavelength Precision Checks indicated that the DOAS analyzer operated normally during the field measurement campaign.

The DOAS analyzer clock was checked daily to ensure the data time stamp was within 1 second of agreement with the DIAL clock.

UV DOAS Data Validation

The gas calibration data, quality control checks, and validated one-minute integrated benzene concentration data are included in the spreadsheet entitled “Shell Deer Park DOAS Data – Valid.xls,” which is included in hard copy as attachment 2 to this report. During field measurements there were 8 one-minute periods when an object blocked the light path, rendering the 1-minute integrated concentration data invalid because of

insufficient light levels; that data is flagged as indicated on the spreadsheet. There were also a total of 17 one-minute data points where an analyzer logger setting apparently caused the 17 points to not log correctly during automated diffraction grating reset intervals. The 17 points are also flagged in the data set.

UV DOAS Assessment, Response, and Reconciliation with User Requirements

As indicated in Data Validation, above, there were 17 one-minute benzene concentration data that did not log correctly during automated grating reset intervals. The logging anomaly was traced to the analyzer buffer memory poll and update intervals, which were set to 5- and 10-seconds, respectively. These poll and update intervals were suitable for previous measurements using 5-minute integrated gas concentration and logged meteorology data; however, the settings were apparently not of short enough duration for continuous logging of gas concentration data at one-minute integrations during grating resets. The 17 one-minute data represents 2% of the 870 one-minute benzene concentration data collected during field measurements.

In the event that a continuous benzene concentration time series data set is desired for comparison with the DIAL measurements, the benzene concentration data was also retrieved from the DOAS analyzer as two-minute integrations and the data is included in the above-referenced spreadsheet.

UV DOAS Measurement Site Notes

Date: February 8, 2010

Site: TOL913, 18th Street, Shell Deer Park. See, attachment 3, DOAS Receiver at TOL913, 02-08-2010.

TOL913 is a floating-roof tank which at the time was used for storage of pyrolysis gasoline, which is a mixture of liquid organic compounds, including benzene. During measurements, Dan Hoyt and I surveyed the DOAS path using a hand-held PID owned by the City of Houston (ppbRae, Model 3000, S/N 594-001534). The PID response (0 – to 130 ppbV as isobutene, highly variable) indicated there was a gas plume downwind of TOL913 near the DOAS emitter, and we detected gasoline-like odors there. Based on the PID survey and odor we surmised that the benzene plume detected by the DOAS was probably not present over the entire length of the optical path.

Date: February 9, 2010.

Site: North Effluent Treatment Area (NET). See, attachment 4, DOAS Receiver at N Effluent Treatment, 02-09-2010.

During measurements, I surveyed the measurement area using the City of Houston's hand-held PID to ascertain if the benzene concentrations recorded by the DOAS were attributable to the Aeration Basin, which was located directly to the north of the most of the length of the path, or, to the two DAF treatment units, located north of the path at the western-most end. The PID response on the downwind side of the Aeration Basin

ranged from 0 to 300 ppbV as isobutene, and odors were typical of wastewater treatment facilities; consistent with my observations of February 5 (see, SUMMA Samples, below), the PID response immediately downwind of the DAF units ranged from 1,000 to 5,400 ppbV, and odors were characteristic of hydrocarbons. In deference to Shell's request to be notified of SUMMA sampling to take duplicates, Dan Hoyt and I attempted to notify a Shell representative of our desire to take SUMMA samples at the Aeration Basin to determine if benzene is emitted there, and were not successful. It is not clear whether the DOAS was recording benzene emissions from the Aeration Basin, the DAF units, or both.

During the period 15:17 to 15:21, the benzene concentrations recorded by DOAS increased sharply. According to a Shell representative, a crude oil tanker ("Esther Spirit") docked upwind of the measurement site may have vented crude oil vapors into the ambient air. The concentration increase was also apparently recorded by the DIAL, the FTIR, and the MAAML.

Date: February 10, 2010.

Site: TOL913. See, attachment 5, DOAS Receiver at TOL913, 02-10-2010, 0935 to 1335, and attachment 6, DOAS Receiver at TOL913, 02-10-2010, 1408 to 1700.

From 09:35 to 13:35, DOAS data was collected at the same 168 m path location as was done on February 8th. Construction of scaffolding started at around 13:15 and was apparently going to block the path signal; the DOAS receiver was moved to a different location, resulting in a 124 m path. It is evident by comparing the measurement results that the shorter path may have been more fully within the benzene plume downwind of TOL913 because the concentrations are greater than those recorded with the 168 m path.

After conferring with the DIAL team, I concluded that the data collected at this location, and the results of SUMMA samples (see below) would be useful for comparing the benzene measurements between the DIAL and DOAS in a plume where multiple VOC species were likely present.

SUMMA Samples

Date: February 5, 2010

Site: NET

At 14:20, I signed in to the DAF Operations Room and met "Caffrey," a control room operator. Caffrey stated that oil is separated from process and site runoff wastewater in the DAF. I explained the purpose of NPL's Tenax-Carbon Adsorption apparatus that we wanted to set up in the DAF area. He confirmed that the sampling location would not interfere with site operations and requested copies of the results of NPL's Tenax-Carbon Adsorption tube samples. The samples were collected downwind of the South DAF from about 15:40 to 16:20.

At 14:30, upon my request, "Mike," who also works at the DAF, escorted me to an area within the NET west of the DAF where process wastewater is initially collected in basins. PID readings at Manhole #4, where wastewater is initially collected, were in the range of 10,000 to 20,000 ppbV as isobutene. PID readings in the general area were on the order of 1,000 to 2,000 ppbV. The area appears to be a significant source of fugitive VOCs.

At 16:37 and 16:41, I collected grab samples using SUMMA canister Nos. 4570 and 4567, respectively, at the same location downwind of the South DAF where the Tenax-Carbon Adsorption Tubes were stationed. PID readings were in the range of 1500 to 2100 ppbV during SUMMA sampling. I relinquished the samples under Chain-of-Custody to Dr. Peter Chen of the City of Houston.

Date: February 10, 2010
Site: TOL913

During the DIAL and DOAS benzene measurements, I decided to collect SUMMA samples for analysis by TO-15 to identify the ambient concentrations of various VOCs. The objectives were to determine the VOC species present, for purposes of the DIAL and DOAS comparison, and to scale the total VOC mass in accordance with the benzene mass fraction to estimate the total mass emissions from TOL913 (see, Action Items, below).

From 15:09 to 16:00, I used SUMMA canister No. 1350 to collect a time-integrated sample at two locations downwind of TOL913. I chose the locations based on felt wind direction and hand-held PID readings. The locations were 59 m NNE of the center of TOL913, and 59 m NNW of the center of TOL913. I relinquished this sample to the City of Houston for TO-15 analysis.

At 15:58, I took a 15-second (approximate) grab sample using SUMMA canister No. 4568 at the location 59 m NNW of the center of TOL913. I relinquished the canister under Chain-of-Custody to Ms. Barbara Bassett-Henderson of Shell, as an approximate duplicate of SUMMA No. 1350 for Shell to analyze. I explained to Ms. Henderson that I did not have two flow-restricted inlets and had to produce a grab sample for Shell. However, as I further explained, it was my view that the samples should be comparable for the intended purpose of identifying the relative ratio of benzene to other identified compounds in the plume from TOL913.

Information Required from Shell Deer Park

1. Chemical composition (laboratory analysis report) of the pyrolysis gasoline in TOL913 on February 8 and 10, 2010.
2. Analysis of SUMMA canister 4568 (relinquished to Shell on February 10, 2010).

Action Items

1. Provide a copy of the analytical results of the Tenax-Carbon absorption samples collected by NPL downwind of the NET South DAF, and of SUMMA sample canisters No. 4567 and 4570 collected by me on February 5, to Caffrey, employed by Shell at the NET.
2. I collected SUMMA sample Nos. 1350 (time-integrated) and 4569 (15 second grab) downwind of TOL913 on February 10, 2010, when PID readings indicated that the samples were probably of the TOL913 plume. The samples were collected during DIAL-DOAS comparison measurements of benzene in a pyrolysis gasoline plume; the analysis by TO-15 may include most of the organic species present in pyrolysis gasoline. The results of the SUMMA samples should be evaluated as follows:
 - a. The TO-15 results should be compared with the TOL913 pyrolysis gasoline analysis to be provided by Shell to determine if there were components of the gasoline that were not analyzed by TO-15.
 - b. The benzene mass ratio of the SUMMA samples should be scaled to the total mass of the compounds identified by TO-15, and the mass ratio (total speciated VOC/benzene mass) could be used to estimate the total VOC mass emissions from TOL913 based on the DIAL benzene measurement results.
 - c. When evaluating the comparison between the DIAL and DOAS measurements of February 10, the species identified by TO-15 should be considered in the context of their potential for spectral interferences. Note: there is no evidence of significant spectral interferences in the DOAS data based on the signal-to-noise ratios.

Attachments

1. Calibration Records
2. Shell Deer Park DOAS Data – Valid.xls
3. DOAS Receiver at TOL913 02-08-2010
4. DOAS Receiver at N Effluent Treatment 02-09-2010
5. DOAS Receiver at TOL913 02-10-2010 0935 to 1335
6. DOAS Receiver at TOL913 02-10-2010 1408 to 1700

Attachment 1. Calibration Records

Gas Calibration Check Date	Purpose	Reference Gas Conc. 2% Accuracy Standard (ppbV)	DOAS Analyzer Response: Benzene Conc. (ppbV)	DOAS Analyzer Response: Benzene Dev. (ppbV)
1/26/2010	Pre-Trip Check	0	0.5	0.1
	AED Laboratory	20.3	21.2	0.3
		71.1	72.3	0.9
		197.5	197	2.6
2/3/2010	Pre-Deployment Check	0	0.5	0.1
	City of Houston Lab	20.3	21.4	0.2
		71.1	73.6	0.8
		197.5	198.3	2.4
2/12/2010	Post-Deployment Check	0	0.2	0.1
	City of Houston Lab	20.3	21.5	0.2
		50	51.8	0.4
		71.1	71.7	0.6
		197.5	197.8	1.3

DOAS Analyzer QC Check Date	Site Location	Analyzer System Check Parameter	Initial System Check	Grating Position Adjusted?	Final System Check	Benzene Wave Precision Channel Shift	Path Light Level (Lux)
2/8/2010	TOL913	1	8		0		
		2	4004		4003		
		3	26		26		
		4	0	N	1		
		5	52.32		52.29		
						0	300

DOAS Analyzer QC Check Date	Site Location	Analyzer System Check Parameter	Initial System Check	Grating Position Adjusted?	Final System Check	Benzene Wave Precision Channel Shift	Path Light Level (Lux)
2/9/2010	North Effluent Treatment	1	8		-3		
		2	4163		4171		
		3	27		26		
		4	4	Y	-1		
		5	60.87		61.04		
						2	520

DOAS Analyzer QC Check Date	Site Location	Analyzer System Check Parameter	Initial System Check	Grating Position Adjusted?	Final System Check	Benzene Wave Precision Channel Shift	Path Light Level (Lux)
2/10/2010	TOL913 (09:41 - 13:33)	1	16		23		
		2	4233		4224		
		3	25		25		
		4	3	N	3		
		5	64.87		64.71		
						2	300

DOAS Analyzer QC Check Date	Site Location	Analyzer System Check Parameter	Initial System Check	Grating Position Adjusted?	Final System Check	Benzene Wave Precision Channel Shift	Path Light Level (Lux)
2/10/2010	TOL913 (14:10 - 16:57)	1	-33		3		
		2	4089		4093		
		3	27		27		
		4	-4	Y	1		
		5	57.89		57.95		
						0	800

Attachment 2. Shell Deer Park DOAS Data – Valid.xls

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
Site: TOL913 (168 m Path)				
2/8/2010	15:20	21.0	1.1	47
2/8/2010	15:22	21.9	1.2	47
2/8/2010	15:24	14.5	1.2	48
2/8/2010	15:26	21.8	1.3	48
2/8/2010	15:28	16.0	1.4	47
2/8/2010	15:30	17.1	1.3	47
2/8/2010	15:32	11.3	1.1	47
2/8/2010	15:34	11.8	1.1	47
2/8/2010	15:36	29.2	1.3	48
2/8/2010	15:38	19.8	1.2	47
2/8/2010	15:40	13.5	1.2	47
2/8/2010	15:42	13.2	1.3	47
2/8/2010	15:44	16.3	1.1	47
2/8/2010	15:46	12.6	1.1	47
2/8/2010	15:48	21.9	1.2	47
2/8/2010	15:50	28.7	2.0	47
2/8/2010	15:52	25.5	1.5	47
2/8/2010	15:54	44.7	1.5	47
2/8/2010	15:56	29.8	1.4	47
2/8/2010	15:58	26.4	1.4	45
2/8/2010	16:00	34.7	1.6	47
2/8/2010	16:02	39.2	2.4	47
2/8/2010	16:04	38.1	1.6	47
2/8/2010	16:06	41.0	2.6	47
2/8/2010	16:08	28.5	1.5	47
2/8/2010	16:10	40.0	2.2	47
2/8/2010	16:12	41.2	2.5	47
2/8/2010	16:14	43.7	2.9	47
2/8/2010	16:16	42.2	2.2	47
2/8/2010	16:18	38.8	1.5	47
2/8/2010	16:20	32.3	1.6	47
2/8/2010	16:22	40.2	2.1	47
2/8/2010	16:24	33.0	1.7	47
2/8/2010	16:26	30.2	1.4	47
2/8/2010	16:28	40.7	2.6	47
2/8/2010	16:30	45.3	2.5	47
2/8/2010	16:32	36.2	1.6	47
2/8/2010	16:34	13.6	1.2	47

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/8/2010	16:36	24.9	1.4	47
2/8/2010	16:38	10.5	1.1	48
2/8/2010	16:40	13.2	1.1	47
2/8/2010	16:42	11.2	1.1	47
2/8/2010	16:44	17.7	1.0	47
2/8/2010	16:46	12.0	1.1	47
2/8/2010	16:48	20.9	1.1	47
2/8/2010	16:50	16.6	1.3	47
2/8/2010	16:52	10.5	1.3	47
2/8/2010	16:54	15.8	1.3	47
Site: North Effluent Treatment Area (148 m Path)				
2/9/2010	10:26	6.7	1.2	55
2/9/2010	10:28	5.7	1.2	56
2/9/2010	10:30	6.7	1.2	56
2/9/2010	10:32	5.3	1.4	56
2/9/2010	10:34	4.4	1.3	55
2/9/2010	10:36	8.7	1.2	55
2/9/2010	10:38	7.2	1.3	55
2/9/2010	10:40	9.0	1.2	56
2/9/2010	10:42	5.8	1.1	55
2/9/2010	10:44	9.1	1.1	54
2/9/2010	10:46	7.8	1.3	55
2/9/2010	10:48	6.8	1.1	55
2/9/2010	10:50	8.3	1.2	55
2/9/2010	10:52	5.7	1.1	54
2/9/2010	10:54	9.7	1.2	54
2/9/2010	10:56	7.1	1.2	55
2/9/2010	10:58	6.6	1.2	55
2/9/2010	11:00	8.0	1.2	55
2/9/2010	11:02	8.3	1.2	55
2/9/2010	11:04	6.7	1.0	54
2/9/2010	11:06	7.2	1.2	54
2/9/2010	11:08	7.2	1.1	54
2/9/2010	11:10	7.8	1.1	54
2/9/2010	11:12	7.6	1.0	54
2/9/2010	11:14	10.6	1.2	54
2/9/2010	11:16	6.7	1.1	54
2/9/2010	11:18	9.3	1.2	54
2/9/2010	11:20	10.1	1.1	54
2/9/2010	11:22	7.1	1.2	54

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/9/2010	11:24	7.7	1.2	54
2/9/2010	11:26	9.6	1.3	54
2/9/2010	11:28	9.2	1.2	54
2/9/2010	11:30	8.8	1.2	54
2/9/2010	11:32	9.2	1.2	54
2/9/2010	11:34	11.8	1.2	54
2/9/2010	11:36	8.2	1.1	54
2/9/2010	11:38	8.6	1.1	54
2/9/2010	11:40	8.8	1.2	54
2/9/2010	11:42	12.7	1.1	54
2/9/2010	11:44	9.2	1.2	53
2/9/2010	11:46	5.0	1.0	53
2/9/2010	11:48	8.4	1.2	53
2/9/2010	11:50	8.9	1.0	53
2/9/2010	11:52	8.4	1.0	54
2/9/2010	11:54	8.2	1.2	53
2/9/2010	11:56	8.7	1.1	54
2/9/2010	11:58	11.8	1.0	54
2/9/2010	12:00	7.0	1.1	54
2/9/2010	12:02	9.0	1.2	53
2/9/2010	12:04	10.5	1.2	52
2/9/2010	12:06	10.7	1.1	53
2/9/2010	12:08	11.7	1.1	53
2/9/2010	12:10	9.9	1.2	53
2/9/2010	12:12	9.6	1.3	53
2/9/2010	12:14	10.7	1.1	53
2/9/2010	12:16	8.6	1.1	53
2/9/2010	12:18	9.4	1.1	53
2/9/2010	12:20	9.8	1.1	53
2/9/2010	12:22	11.3	1.2	53
2/9/2010	12:24	12.8	1.1	53
2/9/2010	12:26	9.8	1.2	53
2/9/2010	12:28	6.6	1.0	53
2/9/2010	12:30	8.3	1.0	53
2/9/2010	12:32	6.6	1.2	53
2/9/2010	12:34	5.1	1.2	53
2/9/2010	12:36	8.3	1.1	53
2/9/2010	12:38	6.8	1.2	53
2/9/2010	12:40	10.3	1.0	53
2/9/2010	12:42	7.7	0.9	53

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/9/2010	12:44	5.9	0.9	52
2/9/2010	12:46	9.5	0.9	53
2/9/2010	12:48	7.1	1.1	52
2/9/2010	12:50	9.6	1.1	52
2/9/2010	12:52	9.5	1.0	53
2/9/2010	12:54	10.3	1.2	52
2/9/2010	12:56	10.5	1.1	52
2/9/2010	12:58	9.1	1.1	52
2/9/2010	13:00	9.2	1.2	51
2/9/2010	13:02	11.1	1.3	50
2/9/2010	13:04	9.8	1.2	50
2/9/2010	13:06	10.5	1.2	50
2/9/2010	13:08	12.7	1.4	50
2/9/2010	13:10	11.3	1.3	50
2/9/2010	13:12	10.5	1.2	50
2/9/2010	13:14	12.4	1.3	50
2/9/2010	13:16	11.8	1.4	49
2/9/2010	13:18	10.1	1.2	49
2/9/2010	13:20	9.9	1.2	49
2/9/2010	13:22	10.9	1.3	50
2/9/2010	13:24	8.9	1.1	49
2/9/2010	13:26	8.7	1.1	50
2/9/2010	13:28	12.5	1.2	50
2/9/2010	13:30	6.0	1.0	50
2/9/2010	13:32	8.5	1.2	49
2/9/2010	13:34	6.8	1.1	49
2/9/2010	13:36	7.8	1.0	49
2/9/2010	13:38	7.0	1.1	49
2/9/2010	13:40	6.6	1.1	48
2/9/2010	13:42	6.9	1.0	48
2/9/2010	13:44	9.2	1.1	48
2/9/2010	13:46	7.6	1.2	48
2/9/2010	13:48	9.5	1.1	49
2/9/2010	13:50	8.7	1.0	49
2/9/2010	13:52	13.0	1.1	48
2/9/2010	13:54	9.9	1.3	48
2/9/2010	13:56	11.8	1.2	47
2/9/2010	13:58	8.0	1.1	48
2/9/2010	14:00	7.2	1.2	48
2/9/2010	14:02	7.7	1.4	48

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/9/2010	14:04	12.1	1.3	48
2/9/2010	14:06	11.9	1.3	47
2/9/2010	14:08	11.5	1.1	48
2/9/2010	14:10	7.7	1.2	48
2/9/2010	14:12	5.6	1.1	48
2/9/2010	14:14	10.7	1.1	48
2/9/2010	14:16	9.1	1.1	48
2/9/2010	14:18	8.2	1.1	48
2/9/2010	14:20	11.7	1.2	48
2/9/2010	14:22	10.9	1.4	48
2/9/2010	14:24	11.9	1.4	48
2/9/2010	14:26	8.6	1.3	47
2/9/2010	14:28	7.1	1.1	47
2/9/2010	14:30	12.5	1.2	47
2/9/2010	14:32	10.2	1.3	46
2/9/2010	14:34	12.2	1.3	47
2/9/2010	14:36	8.5	1.2	47
2/9/2010	14:38	11.4	1.1	47
2/9/2010	14:40	7.9	1.1	47
2/9/2010	14:42	8.2	1.4	47
2/9/2010	14:44	8.3	1.2	48
2/9/2010	14:46	10.5	1.2	48
2/9/2010	14:48	11.1	1.2	48
2/9/2010	14:50	6.7	1.2	48
2/9/2010	14:52	12.2	1.2	47
2/9/2010	14:54	8.8	1.3	47
2/9/2010	14:56	9.0	1.2	48
2/9/2010	14:58	5.7	1.0	48
2/9/2010	15:00	11.6	1.2	48
2/9/2010	15:02	8.5	1.0	48
2/9/2010	15:04	9.0	1.0	48
2/9/2010	15:06	5.2	1.0	47
2/9/2010	15:08	9.8	1.3	49
2/9/2010	15:10	8.9	1.1	49
2/9/2010	15:12	10.0	1.3	49
2/9/2010	15:14	58.8	1.1	49
2/9/2010	15:16	177.0	1.5	48
2/9/2010	15:18	92.0	1.4	48
2/9/2010	15:20	9.3	1.1	49
2/9/2010	15:22	9.6	1.3	49

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/9/2010	15:24	19.5	1.2	49
2/9/2010	15:26	13.8	1.2	48
2/9/2010	15:28	10.2	1.2	48
2/9/2010	15:30	12.8	1.1	48
2/9/2010	15:32	12.1	1.3	48
2/9/2010	15:34	9.1	1.1	47
2/9/2010	15:36	13.3	1.2	47
2/9/2010	15:38	5.6	1.1	48
2/9/2010	15:40	7.1	1.1	48
2/9/2010	15:42	5.4	1.0	48
2/9/2010	15:44	8.0	1.1	48
2/9/2010	15:46	7.6	1.4	48
2/9/2010	15:48	7.8	1.2	48
2/9/2010	15:50	13.3	1.3	48
2/9/2010	15:52	9.3	1.2	48
2/9/2010	15:54	9.8	1.2	47
2/9/2010	15:56	8.3	1.1	47
2/9/2010	15:58	6.7	1.0	48
2/9/2010	16:00	10.4	1.1	48
2/9/2010	16:02	5.3	1.2	48
2/9/2010	16:04	9.2	1.2	48
2/9/2010	16:06	11.4	1.1	48
2/9/2010	16:08	11.4	1.1	48
2/9/2010	16:10	10.5	1.3	48
2/9/2010	16:12	15.3	1.2	48
2/9/2010	16:14	13.6	1.4	48
2/9/2010	16:16	12.1	1.1	48
2/9/2010	16:18	9.8	1.1	48
2/9/2010	16:20	10.8	1.0	50
2/9/2010	16:22	9.8	1.0	50
2/9/2010	16:24	7.9	1.1	50
2/9/2010	16:26	12.0	1.2	48
2/9/2010	16:28	13.3	1.2	49
2/9/2010	16:30	9.1	1.0	49
2/9/2010	16:32	14.3	1.2	49
2/9/2010	16:34	12.6	1.2	50
2/9/2010	16:36	9.8	1.1	50
2/9/2010	16:38	9.7	1.1	50
2/9/2010	16:40	7.7	1.0	50
2/9/2010	16:42	7.3	1.0	50

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/9/2010	16:44	5.1	0.9	50
2/9/2010	16:46	9.6	1.1	50
2/9/2010	16:48	9.8	1.0	51
2/9/2010	16:50	10.1	1.0	52
2/9/2010	16:52	9.9	1.0	52
2/9/2010	16:54	14.2	0.9	53
2/9/2010	16:56	9.6	1.0	53
Site: TOL913 (168 m Path)				
2/10/2010	9:42	6.1	1.5	51
2/10/2010	9:44	10.3	1.4	51
2/10/2010	9:46	8.1	1.3	51
2/10/2010	9:48	7.7	1.4	51
2/10/2010	9:50	2.9	1.5	51
2/10/2010	9:52	2.2	1.4	51
2/10/2010	9:54	5.0	1.3	51
2/10/2010	9:56	3.5	1.3	51
2/10/2010	9:58	10.3	1.2	51
2/10/2010	10:00	9.3	1.4	50
2/10/2010	10:02	2.8	1.4	50
2/10/2010	10:04	7.1	1.4	50
2/10/2010	10:06	5.9	1.4	51
2/10/2010	10:08	6.0	1.4	51
2/10/2010	10:10	3.8	1.4	51
2/10/2010	10:12	7.6	1.5	51
2/10/2010	10:14	12.5	1.3	51
2/10/2010	10:16	13.3	1.5	51
2/10/2010	10:18	8.8	1.5	51
2/10/2010	10:20	12.7	1.4	50
2/10/2010	10:22	8.0	1.4	50
2/10/2010	10:24	11.6	1.4	50
2/10/2010	10:26	16.9	1.1	50
2/10/2010	10:28	13.8	1.4	50
2/10/2010	10:30	8.2	1.6	49
2/10/2010	10:32	10.8	1.5	49
2/10/2010	10:34	7.0	1.5	49
2/10/2010	10:36	8.1	1.5	48
2/10/2010	10:38	17.0	1.6	49
2/10/2010	10:40	19.5	1.8	48
2/10/2010	10:42	12.0	1.5	48
2/10/2010	10:44	3.5	1.5	48

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/10/2010	10:46	12.6	1.5	48
2/10/2010	10:48	14.0	1.4	49
2/10/2010	10:50	24.3	1.6	48
2/10/2010	10:52	48.0	1.7	48
2/10/2010	10:54	20.1	1.7	48
2/10/2010	10:56	17.2	1.7	48
2/10/2010	10:58	19.9	1.6	48
2/10/2010	11:00	34.3	1.9	48
2/10/2010	11:02	10.4	1.4	48
2/10/2010	11:04	7.3	1.5	48
2/10/2010	11:06	6.5	1.4	48
2/10/2010	11:08	9.0	1.5	48
2/10/2010	11:10	10.5	1.5	48
2/10/2010	11:12	32.3	1.7	48
2/10/2010	11:14	27.7	1.7	48
2/10/2010	11:16	21.0	1.5	48
2/10/2010	11:18	14.2	1.6	48
2/10/2010	11:20	8.8	1.5	48
2/10/2010	11:22	14.0	1.5	48
2/10/2010	11:24	26.7	1.5	48
2/10/2010	11:26	13.0	1.3	49
2/10/2010	11:30	19.5	1.4	49
2/10/2010	11:32	9.1	1.6	49
2/10/2010	11:34	9.8	1.4	48
2/10/2010	11:36	5.6	1.5	48
2/10/2010	11:38	11.0	1.4	48
2/10/2010	11:40	13.4	1.5	48
2/10/2010	11:42	5.1	1.5	48
2/10/2010	11:44	4.0	1.3	49
2/10/2010	11:46	6.5	1.4	49
2/10/2010	11:48	9.3	1.4	49
2/10/2010	11:50	9.7	1.5	49
2/10/2010	11:52	6.8	1.3	48
2/10/2010	11:54	7.5	1.4	48
2/10/2010	11:56	29.0	2.1	48
2/10/2010	11:58	17.9	1.5	48
2/10/2010	12:00	15.8	1.7	48
2/10/2010	12:02	17.6	1.8	48
2/10/2010	12:04	25.8	1.7	48
2/10/2010	12:06	54.4	3.6	48

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/10/2010	12:08	47.3	3.1	48
2/10/2010	12:10	40.6	2.7	48
2/10/2010	12:12	31.0	2.1	48
2/10/2010	12:14	19.3	1.5	47
2/10/2010	12:16	17.9	1.6	47
2/10/2010	12:18	68.7	1.6	48
2/10/2010	12:20	55.3	1.4	48
2/10/2010	12:22	64.2	2.2	47
2/10/2010	12:24	24.2	1.7	47
2/10/2010	12:26	76.4	1.6	48
2/10/2010	12:28	49.8	1.8	48
2/10/2010	12:30	38.5	2.5	48
2/10/2010	12:32	126.0	1.7	48
2/10/2010	12:34	58.9	1.8	48
2/10/2010	12:36	28.9	1.9	49
2/10/2010	12:38	22.1	1.5	50
2/10/2010	12:40	25.4	1.6	50
2/10/2010	12:42	15.3	1.5	49
2/10/2010	12:44	24.9	1.7	49
2/10/2010	12:46	18.0	1.6	49
2/10/2010	12:48	15.2	1.4	49
2/10/2010	12:50	7.4	1.7	49
2/10/2010	12:52	13.9	1.5	48
2/10/2010	12:54	8.1	1.4	48
2/10/2010	12:56	23.6	1.8	49
2/10/2010	12:58	19.0	1.5	49
2/10/2010	13:00	17.4	1.4	49
2/10/2010	13:02	30.6	1.7	48
2/10/2010	13:04	27.1	1.8	48
2/10/2010	13:06	58.3	2.0	48
2/10/2010	13:08	26.7	1.4	48
2/10/2010	13:10	24.9	1.7	48
2/10/2010	13:12	51.6	3.7	48
2/10/2010	13:14	48.1	2.8	48
2/10/2010	13:16	20.7	1.7	48
2/10/2010	13:18	19.5	1.8	48
2/10/2010	13:20	27.4	1.8	48
2/10/2010	13:22	40.3	2.6	47
2/10/2010	13:24	49.1	2.5	48
2/10/2010	13:26	31.9	2.0	48
2/10/2010	13:28	59.9	3.2	48
2/10/2010	13:30	136.0	3.1	48
2/10/2010	13:32	26.3	1.8	48

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
Site: TOL913 (124 m Path)				
2/10/2010	14:10	22.1	1.5	59
2/10/2010	14:12	13.7	1.2	59
2/10/2010	14:14	17.6	1.2	59
2/10/2010	14:16	75.9	1.7	59
2/10/2010	14:18	161.0	1.6	59
2/10/2010	14:20	159.0	1.7	59
2/10/2010	14:22	122.0	1.5	59
2/10/2010	14:24	95.5	1.3	59
2/10/2010	14:26	113.0	1.9	59
2/10/2010	14:28	83.5	1.2	59
2/10/2010	14:30	130.0	1.5	59
2/10/2010	14:32	28.8	1.5	59
2/10/2010	14:34	66.8	1.4	59
2/10/2010	14:36	168.0	1.7	59
2/10/2010	14:38	109.0	1.5	58
2/10/2010	14:40	27.7	1.7	59
2/10/2010	14:42	19.9	1.4	59
2/10/2010	14:44	110.0	1.7	59
2/10/2010	14:46	133.0	1.6	59
2/10/2010	14:48	92.9	1.5	59
2/10/2010	14:50	54.0	1.4	59
2/10/2010	14:52	178.0	1.9	59
2/10/2010	14:54	164.0	1.7	59
2/10/2010	14:56	92.6	1.9	59
2/10/2010	14:58	172.0	1.8	59
2/10/2010	15:00	64.1	1.1	59
2/10/2010	15:02	99.4	1.4	59
2/10/2010	15:04	176.0	1.9	59
2/10/2010	15:06	102.0	1.4	59
2/10/2010	15:08	45.3	1.1	59
2/10/2010	15:10	65.2	1.3	59
2/10/2010	15:12	39.5	1.1	59
2/10/2010	15:14	118.0	1.5	59
2/10/2010	15:16	154.0	1.9	59
2/10/2010	15:18	94.9	1.4	59
2/10/2010	15:20	101.0	1.3	59

Date	DIAL-DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/10/2010	15:22	51.2	1.4	59
2/10/2010	15:24	35.5	2.0	59
2/10/2010	15:26	8.2	1.1	59
2/10/2010	15:28	5.1	1.1	59
2/10/2010	15:30	9.5	1.4	59
2/10/2010	15:32	56.6	3.5	59
2/10/2010	15:34	67.1	2.5	59
2/10/2010	15:36	45.4	2.5	59
2/10/2010	15:38	108.0	2.6	59
2/10/2010	15:40	156.0	1.7	59
2/10/2010	15:42	127.0	1.6	59
2/10/2010	15:44	108.0	1.5	59
2/10/2010	15:46	41.1	1.7	44
2/10/2010	15:48	37.5	1.6	59
2/10/2010	15:50	106.0	1.5	59
2/10/2010	15:52	132.0	1.8	59
2/10/2010	15:54	99.5	1.4	59
2/10/2010	15:56	139.0	2.0	59
2/10/2010	15:58	124.0	1.7	59
2/10/2010	16:00	53.9	1.3	59
2/10/2010	16:02	80.7	1.3	59
2/10/2010	16:04	71.0	1.9	59
2/10/2010	16:06	50.7	1.6	59
2/10/2010	16:08	113.0	1.5	59
2/10/2010	16:10	90.7	2.2	59
2/10/2010	16:12	74.7	1.1	59
2/10/2010	16:14	89.5	1.1	59
2/10/2010	16:16	91.7	1.3	59
2/10/2010	16:18	118.0	1.4	59
2/10/2010	16:20	157.0	1.8	59
2/10/2010	16:22	178.0	2.0	59
2/10/2010	16:24	192.0	2.1	59
2/10/2010	16:26	105.0	1.7	59
2/10/2010	16:28	147.0	1.8	59
2/10/2010	16:30	170.0	1.7	59
2/10/2010	16:32	149.0	1.6	59
2/10/2010	16:34	179.0	1.5	59
2/10/2010	16:36	164.0	1.6	59
2/10/2010	16:38	171.0	1.6	59

Date	DIAL- DOAS Time	Benzene Conc. (ug/mE3)	Benzene Dev. (ug/mE3)	Light Level (%)
2/10/2010	16:40	108.0	1.4	59
2/10/2010	16:42	168.0	1.6	59
2/10/2010	16:44	162.0	1.7	59
2/10/2010	16:46	181.0	1.8	59
2/10/2010	16:48	211.0	1.9	59
2/10/2010	16:50	166.0	2.0	59
2/10/2010	16:52	156.0	2.0	59
2/10/2010	16:54	133.0	1.9	59
2/10/2010	16:56	76.0	2.4	59

Attachment 3. DOAS Receiver at TOL913, 02-08-2010



Attachment 4. DOAS Receiver at N Effluent Treatment, 02-09-2010



Attachment 5. DOAS Receiver at TOL913, 02-10-2010, 0935 – 1335



Attachment 6. DOAS Receiver at TOL913, 02-10-2010, 1408 – 1700

